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SIGMA XI QUARTERLY

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SIGMA XI QUARTERLY

EDITORIAL COMMITTEE

FLOYD KARKER RICHTMYER
EDWIN EMERY SLOSSON
HENRY BALDWIN WARD
EDWARD ELLERY

VOL. XII JUNE, 1924 No. 2

EDITORIALS

IMPRESSIONS OF THE SPRING MEETING OF THE EXECUTIVE COMMITTEE

"I want to tell you how strongly I was impressed at the meeting of the Executive Committee of Sigma Xi at Ann Arbor with the possibilities of developing the Society as a highly influential national organization for the encouragement and support of science in America.

"With chapters in forty-two colleges, technical schools, and universities, and an alumni roll of eighteen thousand individuals, Sigma Xi is now in a position to assume a place of great importance in promoting scientific research both in and out of the higher educational institutions of the country.

"However, to acquire this position will require the development of a much greater coöperation and solidarity among the chapters, and among the alumni members, than apparently at present exists. I believe that this development can be effected.

"My feeling, therefore, with regard to the present and future policy and activity of Sigma Xi is that we should give an intensive attention to the matter of an immediate movement of the Society, along lines of national organization and usefulness. The chapters should come to realize that they are related, not independent units, and the alumni to feel that their severance from immediate active membership in the chapter is no severance at all from Sigma Xi, but rather a change that gives them a larger opportunity and responsibility to help forward the aims of the Society.

"I believe this understanding can be realized, and shall be glad to part, as member of the Executive Committee, to help bring about this realization."

VERNON KELLOGG

"The recent meeting of the Sigma Xi Executive Committee, the first I was privileged to attend as Alumni representative, gave me a clear conception of the tremendous opportunity that faces the organized body of Sigma Xi alumni in advancing research, and in increasing popular understanding of the importance of science and research in sustaining and developing civilization. The traditions of Sigma Xi under the guidance of the inspiring leadership of its officers gives promise that this opportunity will be grasped."

C. E. DAVIES

"There were two outstanding impressions that one gained from our recent committee meeting. One is the tremendous possibility of using the influence of our thousands of alumni in fostering the development of research in this country, and the other is the attitude of the officers who see this opportunity so clearly and are devotedly anxious to make the best use of it.

"The attitude of the officers of the Society in making the organization a strong influence in behalf of research among its thousands of alumni members is exceedingly gratifying. One of the outstanding difficulties in the successful attainment of the high ideals set for the Society is the local view-point of chapter members. It is difficult for them to realize that the honorary feature of the Society is really of very secondary importance, and that the promotion of research is the chief object. It is hoped that chapter members everywhere will respond to the leadership of the national officers in this broader field even though from the local view-point the importance of their activity may not be easily realized. The Society is now one of the largest, if not the largest scientific organization in the world, and its possibilities are great."

G. W. STEWART

"The session of our committee in Ann Arbor left a permanent impression of the growth and vigor of the society. New opportunities, larger demands upon its service, and a broadening of the field for the encouragement of research were evidenced in numerous ways. While some might regret the increasing responsibilities that are thrown upon officers and the inseparable demand for more machinery and aid in carrying out the work of the organization, yet all must welcome these evidences of development from a more or less local to a thoroughly national organization. So long as Sigma

Xi continues to emphasize its primary object, encouragement of research, and to direct all its energies towards the accomplishment of that end, no one need fear expansion or hesitate to welcome any opportunities that present themselves."

HENRY B. WARD

SIGMA XI CLUBS

We are glad to report to members of Sigma Xi that there are now a number of Sigma Xi clubs functioning at various institutions. At Michigan Agricultural College, such a club has been organized, with Dean Bissell as Chairman. There are, at that institution, twenty-five professors and instructors who are members of Sigma Xi.

The Sigma Xi Club at the University of Oklahoma has been very active during the year. On the faculty there are twenty-three members of Sigma Xi. They held five meetings during the last academic year, and the college has been instrumental in initiating and organizing several movements looking to the promotion of research at the university. At the suggestion of the club, a Board of Regents has authorized a sum of money to be used as research scholarships. During the activities of the club, a periodical librarian has been added to the library staff.

There is an active Sigma Xi Club at Carleton College, of which Dr. A. T. Lincoln is president. It numbers sixteen Sigma Xi members. It holds regular meetings which are open to the science teachers of the high schools and advanced students.

The Sigma Xi Club at the University of Wyoming has held three large meetings during the year, with addresses by Dr. Slosson, Dr. Seashore, and a representative from the Forest Products Laboratory of the University of Wisconsin.

The Sigma Xi Club at the Oregon State Agricultural College numbers twenty-nine members. Besides holding one meeting jointly with the faculty of the University of Oregon, it has held four meetings of its own at which papers were presented on research problems under investigation at the Agricultural College.

SPRING MEETING OF THE EXECUTIVE COMMITTEE

A meeting of the Executive Committee was held under the auspices of the Michigan Chapter at Ann Arbor, May 9 and 10. Present: President Richtmyer and Professors Pegram, Eigenmann, Stewart, McClung, Ward, Ellery, Dr. Kellogg, and Mr. C. E. Davies.

1. The sub-committee on conventions reported that Dr. Frederick F. Russell, General Director of the International Health Board, had accepted an invitation to be the speaker at the Washington Convention, and that President Coolidge had tentatively accepted an invitation to be present and speak.

It was voted that arrangements for the Convention should be made by the sub-committee in coöperation with the local committee of arrangements of the American Association for the Advancement of Science.

2. It was voted that the national constitution should be printed in suitable form and that it should be distributed as occasion arises. Chapters will be expected to pay for the copies they order.

3. Professors Pegram, Ellery, and McClung were appointed a special committee to consider a revision of the procedure for installation of new chapters and report at the December meeting of the committee.

It was voted that arrangements be made to install the chapter at the California Institute of Technology under circumstances that shall be advantageous to the chapter and society.

4. The question of expulsion of members for cause was discussed at length. It was moved that no definite action be taken at this time.

5. The secretary was authorized to canvass the field of possible candidates for a board of editors for the Quarterly and to make nominations to the members of the Executive Committee by mail.

Professors Stewart, Ellery, and Mr. Davies were appointed a special committee on the Quarterly, this committee to report at the December meeting.

6. Inquiries regarding possible charters were received from several institutions. Careful consideration was given to each, but definite action was postponed to a later meeting.

7. The president reported an inquiry from the Minnesota Chapter as to whether graduate work in the department of education would constitute a proper basis for election to membership in Sigma Xi. President Richtmyer presented correspondence that had passed between him and the chapter in the matter, and the committee voted to approve the president's letter.

8. Professor Stewart presented a resolution regarding nominations for members of the Executive Committee and president. It was voted that a retiring member of the Executive Committee be ineligible for re-election. Professor Pegram was asked to present for the consideration of the Executive Committee at its December meeting formal suggestions regarding eligibility of candidates for election to the presidency.

9. The matter of representation of the society at the meeting of the British Association at Toronto was referred to Dr. Kellogg and President Richtmyer with power.

10. Professor Stewart presented a letter from President Aydelotte of Swarthmore College regarding possible extension of the society to other countries.

It was voted to re-affirm the position taken by the Executive Committee in 1918 regarding international extension of the society and that the present committee regard as particularly important the extension of the society to Canadian institutions.

11. A special sub-committee on alumni activities, consisting of Mr. Davies, Professors Stewart and Ellery, reported as follows:

a. That a definite research program be formulated,

b. That the work of the secretary's office be organized so as to keep the vast body of alumni as well as the chapters in constant touch with the national society,

c. That the periodical publication of a list of members is desirable,

d. That alumni centers should be developed in large cities,

e. That the society should publish, either in connection with the present Quarterly or as a separate publication, a journal that shall be of especial interest to alumni,

f. That alumni should be given opportunity to pledge payment of dues for which they would receive the journal and a year-book of correct addresses.

12. In connection with the report of the sub-committee it was resolved that the Executive Committee approve in principle the expansion of the Quarterly into a journal attractive to the alumni

and open to subscription from alumni and active members without materially changing the present policy of the Quarterly and its distribution. In order to cover the necessary expense of this project as well as the other increasing expenses of the secretary's office, it was voted to recommend to the society an increase in the annual assessment from seventy-five cents to a dollar.

13. It was voted that a special committee be appointed to formulate plans for the administration of funds contributed by alumni for fellowships or for other means of promoting and supporting research. This committee was asked to prepare a report for the December meeting. Later, the president appointed the following: Mr. Davies, Chairman, Dean Pegram, and Professor Stewart.

14. The committee voted to approve in principle the formation of alumni centers, and Mr. Davies was requested to investigate the possibility of organizing the alumni in New York City and vicinity. President Richtmyer and Secretary Ellery were authorized to participate in a meeting of New York City alumni if, and when, such a meeting is arranged.

15. In connection with the question of alumni dues, the Alumni Committee was requested to make report at the December meeting.

16. The secretary was directed to express to the Michigan Chapter the deep appreciation of the members of the Executive Committee of all the attentions and courtesies extended to them during their sojourn at Ann Arbor.

EDWARD ELLERY, *Secretary*

REPORT OF DR. ROY L. MOODIE, SIGMA XI FELLOW

SCRIPPS INSTITUTION FOR BIOLOGICAL RESEARCH, LA JOLLA, CALIFORNIA, JANUARY 30, 1924

"At the present time I am working up the literature and writing results of my observations here at the Biological Station where there is a good laboratory room. My work is divided into three lines of study:

a. Observations on the pathological material of the Rancho la Brea, Pleistocene, Vertebrates in the collections of the Los Angeles Museum at Exposition Park. Here Dr. W. A. Bryan, the director, has placed everything possible at my disposal. There have been prepared for me about 150 photographs of the diseased fossil bones, especially of the saber-tooth tiger, Smilodon, which seems to have been especially subject to injury and infection. The other abundant species from these deposits, the dire wolf, Aenocyon dirus, is not yet so well known, since the pathological material has not been entirely segregated from the thousands of healthy skeletons of this huge wolf. A final decision regarding many of the conclusions to be drawn from this study of Pleistocene pathology cannot yet be safely made. The above-mentioned photographs will, many of them, serve as illustrations for the finished memoir on this collection which I have in preparation. Accompanying the photographs there is a great quantity of notes written with the objects before me and intended for final publication after revision and comparison with other similar pathological lesions, human and animal. Access to a medical library will be necessary to accomplish this part of the work. Many wonderful drawings of the more typical lesions are being made for me, and I anticipate a memoir of which the Society of Sigma Xi will be proud. Before finishing this study it will be necessary for me to go to Berkeley to study material there. So far as this phase of the work goes, then, I can only report progress. There are many wonderful new facts to be added to our knowledge of Paleopathology from the study of the pathological material of the Rancho la Brea, facts from which later we shall be able to draw far-reaching conclusions as to the status of pathology during the Pleistocene.

b. Observations on the pathological material at the San Diego Museum of Anthropology (mostly prehistoric Peruvian).

The same plan has been followed at San Diego as at Los Angeles, and I have received exceptionally courteous treatment from the officials in charge. At this museum there have been assembled in one large room a vast amount of skeletal material relating to the prehistoric pathology and surgery of certain Indians. Only yesterday I completed my observations on a series of cancerous tumors in certain prehistoric skulls from Peru. They are the only tumors of this type known in the field of Paleopathology. A special paper with the title "Prehistoric Cranial Hyperostoses from Peru," illustrated by photographs and drawings is almost ready for press. Another special paper with the title "A Prehistoric Surgical Bandage from Peru," illustrated by four photographs reveals a considerable insight in medical affairs by these primitive people. This paper is about ready to send off. The collection at San Diego is so extensive that I cannot hope to complete my work there this year. I shall probably publish some of the more striking results separately.

Here, too, I have a large note-book full of notes written with the material in front of me. There are something over 100 drawings and excellent photographs accompanying the notes. This indicates, of course, that only the observational side of the work has been done, leaving other aspects of the study to some future time. Especial attention has been paid so far to the study of injuries to the head. This has been done in part to help solve the mysteries surrounding the primitive and ancient surgical art of trephining, of which there are numerous examples in the collection. Many of the more striking examples have been studied and either drawn or photographed. It is my hope and plan to prepare, finally, a descriptive, illustrated catalogue of this collection, the most striking of its kind in the world.

c. Preparation of a book on the Extinct Amphibia.

I have in mind for this work a not too technical account of this group of vertebrates, and shall hope to give, briefly, all that is known of these animals. Just recently I have been reviewing the literature relating to the origin of the amphibians; preparing a discussion on amphibian footprints and securing many new and otherwise unknown illustrations; securing material and slides for the study of the histology of the skeleton of the Stegocephalians. Nothing final has been accomplished save the accumulation of notes and illustrative material. But I do report progress.

I mentioned to the committee the desirability of studying the habitat of the prehistoric Indians of Southern California, in an effort to ascertain what influence the region may have had on the well-being of this primitive people. I find this an exceptionally difficult task, and while I have made many notes, photographs, and observations during the ride of over 6500 miles of roads of Southern California, yet I am not sure what the results will be, if any. I have made arrangements with a photographer in San Diego to visit the Coachella Valley with me in April, he to make some two hundred photographs in exchange for his expenses.

During the many trips I have made, I have seen and examined many fossil deposits containing both vertebrates and invertebrates, but this has been chiefly for my own satisfaction in learning the lay of the land stratigraphically. Nothing new or particularly interesting has yet developed from these observations.

Funds have always been placed promptly at my disposal by Mr. Pegram, and this has greatly facilitated the work."

ROY L. MOODIE

THE VACUUM—THERE'S SOMETHING IN IT

ADDRESS AND EXPERIMENTS GIVEN AT THE ANNUAL CONVENTION

BY W. R. WHITNEY

DIRECTOR, RESEARCH LABORATORY, GENERAL ELECTRIC CO.

We humans want better minds, broader horizons, and greater understanding. These scientists assembled here are all at work in their respective fields searching for new truth, to improve the process by which our minds, our horizons, our powers, and our outlooks grow.

When, in the middle ages, all the great cathedrals of the world were being built, the mentality of the world seems to have been suddenly directed to systematic subordination rather than to active appreciation, of creation, to acquiring salvation, or "safety first," rather than knowledge or understanding. To-day you scientists, in seeking truth, think of "safety first," last.

We are told that if the total age of mankind be expressed as the life of a man of fifty years, and if he then looks back upon his progress, he will see that what marks his greatest advancement are events occurring in the most recent years. For example, such a 50-year man now sees that he had not learned to scratch the simplest records on stone until his forty-ninth year. All the immense advantages of printing have only existed three months for him. The uses of steam, which now seem so necessary, were acquired only three or four days ago. The uses of electricity, street cars, lamps, and telephones (which did not actually begin until about 1880) arrived day before yesterday to this 50-year mankind. The automobile, wireless, X-rays, radium, and most of the things which occupy our interests to-day, were actually discovered on this particular fiftieth birthday.

The power outside of his own muscles which, during the past two or three months, he had learned to control, has given him nearly twenty horsepower, or one hundred man power, for every man in the country. Therefore it may almost be said that it makes only one per cent difference whether all the men work like horses or not. Guidance of power applications is, however, man work, because there are no automatic mentalities. Almost everything but thinking

may be artificially done, but knowledge and understanding must be actively sought and acquired. Man is the only animal who can do this.

Scientists know that research always discloses new parts of an infinite unknown. Mathematically, the enticing, helpful "unknown" increases as men continue to subtract from it. Progress in every line of experimental science follows the same law. The apparently narrow path gradually expands into unlimited, unexplored territory. With his new tools and his increased speed of communication, man finds that he can advance into the unknown faster than he can keep his rearward communication lines fully open, and so children seem to learn so much more than we did when we were kids. The scientists of the twentieth century are legion. They were anathema a short time ago. There is more chemistry in the atom now than there was in all "inorganic" chemistry a few years ago. There is more in the sugars now than there was in all "organic" when I studied it. There is more immunity in blood, and more heredity in the microscopic chromosome, than there was in all physiology or biology only a short time back. There is about as much crystal structure research by X-rays now as there was mineralogy when Agassiz came to America.

There is special reason for my bringing before this group of scientists such a narrow field as that which I have chosen. It seems to me desirable that the applications of new knowledge be often distributed throughout the separate sciences. In fact, that is probably the main advantage of an association of this kind and of such meetings as to-night's.

I chose to speak about the *vacuum* because I am interested in it, I want to show that in a vacuum, of which one might say "there is nothing in it" (and surely less than in anything else), there is, indeed an endless amount of interest and utility. The American public now buys over a million dollars' worth of glass vacua a week, but this is far from being the most interesting part of the subject.

Everybody pretends to know that "Nature abhors a vacuum." But the man who started that tale merely meant that a good vacuum was hard to produce. As probably no one has ever made a vacuum with less molecules of gas in a cubic inch of it than there are people in the world, we can maintain that perfection in vacua is still precluded by Nature.

My object is to review some studies in vacua so as to create the

impression that any one may well do research work there, but also certainly anywhere else with pleasure and profit.

We all know that we see at night largely by the aid of vacuum lamps. Through other vacuum lamps, called X-ray tubes, we also see through opaque bodies. The light which illumines our microscope specimen has its analogue in the X-ray light which shows us the crystal structure of matter and the electrical formulae of chemical atoms. Our trans-continental telephony is possible through vacuum tubes which, in various forms, also permit our wireless broadcasting, wireless reception, and amplification from the most remote stations. The workman who keeps his hot coffee in a thermos bottle is clearly indebted to Sir James Dewar's application of the vacuum, but the scientist is still more indebted to it. All our steam power plants, including turbines, owe their success to vacua.

The latest arrival in the family of the chemical elements (hafnium) was discovered through use of its hiding place as an X-ray tube anode, which disclosed the new element, and our list of possible elements was rounded off by Moseley's study of the X-ray spectra just in time to meet the wonderful discoveries of J. J. Thomson and Aston. The latter showed that most of the elements, supposedly simple, are still mixtures of two or more similar elements (isotopes), while Professor Thomson disclosed through experiments, also in partial vacuo, a whole series of new atomic compounds by the positive ray method.

While the vacuum was not essential to the work of Millikan in isolation of the electron, yet the earlier work by Thomson and others, and much of the recent work on this ultimate constituent of matter, have been necessarily carried out *in vacuo*. To-day there seems to be no end to the studies which can be based on the fact that any atom or molecule of material may be separated electrically into a positively charged ion (carrying most of the mass) and a negatively charged electron (carrying most of the current).

These two interesting entities may be followed through their activities, and it is by these activities that we are now enabled to rectify alternating current and also produce alternating current from direct. By means of vacuum tubes we may now also produce from current of one alternating frequency, current of all other desired frequencies, and this has opened up a broad new field of high frequency power studies.

To give some idea of the extent to which vacuum studies may

affect remote fields, let me mention chemical catalysis, the secret of most reactions of life. For example, it is known that mercury vapor in a vacuum, when illumined by light of a certain wave-length, can absorb that light and turn its energy over to hydrogen, if hydrogen be present, so that this, in turn, will reduce such substances as cold copper oxide. Similar facts will probably be found to contain the explanation of the catalytic action of sunlight on growing plants.

And so the studies of phenomena *in vacuo* may lead us into the most widely separated fields. The experiments which I have chosen for this evening are illustrations of this fact, and you must not therefore expect them to be very connected nor very closely related.

One great use of vacuo is in incandescent lamps. I burn out an ordinary tungsten lamp by raising its voltage above normal. It will endure for a few minutes only, but will give a light perhaps five times as efficient as we usually get. It dies because the tungsten either vaporizes or melts. It is for this reason that commercial lamps are made so that at normal voltages they will burn on the average of one thousand hours. If we were satisfied with a shorter life we could have a more efficient light. Much study has been made of distillation of metals *in vacuo*, and on methods for returning the distilled metal to the filament, or of making it invisible or white when it has deposited on the glass. Naturally we are always on the lookout for metals, such as the newly discovered hafnium, which might possibly live longer as filaments than tungsten now lives. Thirty or forty years of research work had been spent on vacuum incandescent lamps before Dr. Langmuir showed us how to make still better lamps by putting argon and nitrogen into the bulb.

An experiment was made to show that a metal distilling *in vacuo* proceeds in straight lines. By this process the shadow of an interposed star was left on the surface of a vacuum bulb after gold had been distilled from a point in the center of the walls. This fits in with the knowledge gained from the kinetic theory of gases where the "mean free path of a moving molecule is a function of the degree of vacuum."

The historic Hittorf experiment has shown where, of two paths, the luminous path in partial vacuum is the longer way between the electrodes (several feet) instead of the shorter (a millimeter) and this now fits in with the modern conception of ionization of gases for luminosity.

The historic Edison effect was discussed and its relationship to pure thermionic currents shown. Electrons, as negative charges,

distil from a heated filament and pass under voltage-drop across a vacuum to an electrode, now commonly called the "plate" in wireless tubes. This pure emission current is the basis for the so-called rectifiers because only when the filament is negative does any current flow across the gap. When gases are present greater current may be carried because of the ionization of the gases, and so the tungar rectifiers, containing a little argon, and the older mercury vapor rectifiers, involve the same principle. Without some gas present the negative electrons by their very concentration constitute a space charge which limits the current. This space charge is removed by the ions produced within the gas introduced.

When we interpose a grid or inter-connected wires between the hot filament and the plate of the above 2-electrode tube, we have what we now so commonly use in wireless for receiving, for amplifying, and for production of high frequency currents. The discovery of the controlling or triggering action of the intermediate electrode was made by De Forest. A negative charge applied to this third electrode or grid may easily stop all current from the hot filament to the plate. As it takes practically no energy to charge this grid, only a token of energy (voltage), the slight power attained from a wireless antenna in its fluctuation may be used to control or to trigger, or to let through corresponding jolts of much greater energy, which are, in turn, supplied by a local battery or power circuit.

In the experiments shown an ordinary incandescent lamp was burning on the above "local" energy which passed negative ions from the hot filament of a pliotron, or 3-electrode tube. The grid, or antenna—wire, was sticking up from the tube so that it could "pick up" the induced charge from a rod of insulating material which was merely rubbed with a piece of paper to charge it. The charges so produced on the rod caused the lamp to go out, or light up, as it was brought near to, or removed far from, the exposed end of the grid wire.

As the negatively charged grid cuts off the current of the 3-element tube, so an external magnetic field will also do it in the 2-element tube by so directing the moving electrons that they cannot reach the plate. Such a device called the magnetron was shown. This particular magnetron made up of a cylindrical plate and a central filament only, had a coil of wire wound on the outside and a feeble current was sent through the coil from a cell. The magnetic field produced within the coil by this current was about equal to that of

the earth's magnetic field, so that by moving the whole apparatus about in space, at one time adding to the earth's field, at others opposing it, the direction of the earth's magnetic field could be disclosed by a meter.

Another useful vacuum tube of this type is one in which the magnetic field of the filament current itself cuts off the electrons so that they will not reach the plate. By this tube, "the axiotron," the frequency of an alternating current may be doubled or direct current be changed into alternating.

Another vacuum tube is the photo-electric cell. One of these was shown connected with a relay so that when light shone upon the cell a burning electric lamp was extinguished, and was relighted on cutting off the light from the photo-electric cell.

This photo-electric cell led to the next experiment. One of these vacuum devices was made to represent the ball of a crude eye, which was connected to a so-called nerve leading to a "brain." The nerve was merely a long box having electrical capacities and suitable amplifiers or 3-electrode tubes within. The capacities served to slow down the apparent rate of flow of the feeble current from the artificial eye so that lamps along the top of the box or "nerve" would light up, one after another, as the impulse from the "eye" passed along by that path of the nerve. After the last lamp was thus lighted up by these amplified currents an electric bell rang to indicate reception at the brain-end of the circuit. This was not shown as a replica of a real nerve, but as an application of the vacuum tube which amplified the little energy available and necessary for the experiment.

In order to show another vacuum product (an X-ray tube) an effect of X-rays not usually shown was demonstrated. Three rubber balloons suspended close together were first charged electrically by rubbing on the head of the speaker. They then repelled each other and stood stationary in space as at the corners of a large triangle. As soon, however, as a feeble beam of X-rays was projected towards them they quickly discharged and fell to their original position in contact with one another. This is the basis of a method for measuring the intensity of beams of X-rays.

References were made to the various applications of X-rays now being studied as in the study of internal structure of crystalline chemical compounds and elements. Cathode rays, the negative ions of pure thermionic emission when speeded up by excessive voltage, produce by their impact, X-rays characteristic of the material on

which they impinge; one may say characteristic of the positive nucleus of the atom of the substance of the target. It is through this fact that the X-ray spectra of the elements are arranged in the same order as the atomic weights in the table of Mendelejeff and by this very method the newest known element, hafnium, has been recently added to the known metals.

With higher voltages the velocity of the cathode rays (or electrons) always increases. In the X-rays thus far produced, however, the penetration is practically limited to less than a quarter of an inch of lead. It is interesting to note that the similar rays for radium, the so-called gamma rays, will penetrate nearly a foot of lead. This corresponds to an exceedingly high electromotive force.

An apparatus was shown, devised by Dr. Hull, which was essentially a 2-electrode vacuum tube, the hot tungsten filament having a little thorium in it. At a certain temperature this thorium diffuses to the surface. This thorium surface then has the power of emitting perhaps a hundred thousand times as many thermions as pure tungsten at the same temperature. A lamp was lighted in the experiment by using this thorium emission current. The tube also contained a little gas. When the lighted lamp was short-circuited, for an instant the increased potential on the vacuum tube caused positive ion bombardment of the filament and tore the torium all off so that the load (the lamp) could no longer be "carried" by the electron current. By preheating the filament for a few seconds only, a layer of thorium diffused anew to the surface of the filament, and then at the previous lower temperature the lighting current was carried again. This was mentioned as a proof of the production of a layer of thorium on the tungsten only one atom deep. This is confirmed by experiments on partial recovery of the surface and supported by thousands of successive repetitions of this experiment on one filament. The production of high frequency current by means of pliotrons was shown and an ordinary incandescent lamp was lighted by being brought within a foot of a coil which was carrying the current of several million cycles. This was said to be about as near to wireless transmission of power as we now have. This high frequency principle is also being used by Professor Northrup of Princeton for special heating furnaces.

Part of the time of the address a loud speaker devised by Dr. Hewlett was in use. This consisted of a 26″ flat conducting disc in a magnetic field. The vibrations of the disc corresponding to the

voice currents produced the sound waves without the intervention of a horn. The use of vacuum tubes in this device consisted in the following:

A microphone was placed near the speaker and the sound waves of his voice caused to be generated in this microphone feeble electromotive forces which were applied to the grid of a pliotron. These feeble electromotive forces caused relatively large variations in the electric current flowing between filament and plate, which in turn were used to secure larger electromotive forces to be applied to the grid of another pliotron. By the use of several amplifying pliotrons the original feeble electrical currents were multiplied several thousand times and supplied to the loud speaker which reproduced the original sounds with many times the original volume and great faithfulness of quality. To operate this amplifier of pliotrons required a direct current of several hundred volts. This was obtained by first transforming the power from the ordinary alternating current lighting circuit to a relatively high voltage, next rectifying this high voltage alternating current by means of kenotrons, and finally smoothing out this pulsating current by means of appropriate electric circuits.

The high degree of faithfulness of reproduction realized in this loud speaker is due partly to the absence of a horn, eliminating horn resonance (one of the usual sources of distortion in a speech reproducer), and partly to the method of vibrating the diaphragm by forces which are distributed fairly uniformly over its surface, instead of being acted upon in a very limited region, as is the case in most other loud speakers. This feature eliminates rattling and ringing of the diaphragm or the production of high overtones by the diaphragm vibrating in its partial modes.

SIGMA XI CLUBS

CHAPTER	PRESIDENT	VICE-PRESIDENT	SECRETARY	TREASURER
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